REMARKS/ARGUMENTS

In the Office action dated March 24, 2004, the Examiner objected to the drawings because of a missing reference number in Fig. 4. This deficiency has been corrected by this Amendment.

The Examiner also objected to the Specification because of typographical errors on page 3, 8, and 10. These errors have been corrected by this Amendment. In addition, another typographical error has been corrected on page 5 of the Specification.

The Examiner objected to the use of the well-known acronyms GTE. LTE and IFF in the Claims. These acronyms have now been spelled out by this Amendment

In the Specification, Pages 3, 8 and 10 are amended.

In the Claims, Claims 3, 8 and 11 are amended.

The Invention

This invention provides a vector based method of automatic color misregistration removal and enhancement, for characters having thin line components therein, such as Kanji and Chinese characters, caused by CCD based images and other scanning devices. The difficulty in scanning these characters is that the characters include lines ranging between very broad to very thin. The problem of color misregistration is exacerbated by the very thin portions of these characters. Other alphabets having a combination of very thick and thin lines include Arabic, Hebrew, Greek, and Cryllic, and share this problem. At the location of a transition to a very thin stroke, the scanned data has insufficient information from the surrounding areas to correct any damaged pixel in the scanned character. Any attempt at correction through interpolation or smoothing will likely make the situation worse.

The technique of the invention is a method of image analysis using three-dimensional color determinant mathematics. Before the three-dimensional color vector determinant method of the invention is executed, certain detection criteria must first be satisfied to detect a misregistered pixel. One may first find an edge pixel position and confirm that this is a text region. After an edge is detected, using the kernel of Equation 3, the pixel in questions need to be identified as to whether it is part of an alphabet character.

Color misregistration is caused by misalignment of a color channel *e.g.* red. If the red channel is misregistered, then color fringing of red and cyan in the left and to the right occurs. In the same way, misregistration of the green channel will cause color fringing of green and magenta. Moreover, for blue, color fringing of blue and yellow occurs surrounding the text.

If maximum color misregistration is assumed, the color-fringing vector Pa and Pb may be represented by Eqs. (7) and (8):

$$\text{Ideal misregistration } Pa = (Ra, Ga, Ba) = (1, 0, 0) \tag{7}$$

$$\text{Ideal misregistration } Pb = (Rb, Gb, Bb) = (0, 1, 1) \tag{8}$$

Eqs. (7) and (8) span a two-dimensional color space where, if the image contains red color misregistration, the color vector Pa and the color vector Pb must be in the two-dimensional vector space spanned by the vector in Eq. (7) and the vector in Eq. (8). In other words, if there is color misregistration, color-fringing vector Pa and color fringing vector Pb may be described as linear combination of the vectors in Eqs. (7) and (8). If no red color channel misregistration is present, then the color vector Pa and color vector Pb must be in the null space spanned by the vector in Eq. (7) and the vector in Eq. (8). The notation for the null space of red color misregistration is Nrm, and is calculated by:

$$Nrm = (0, -1, 1) \quad (9)$$

Following the notation shown in Fig. 4, where Pa = P-1, and Pb = P1, to calculate and estimate the amount of red color misregistration, the control vector volume span by the three basis vectors Nrm, P-1, and P1 must be determined. A three-dimensional matrix containing these three vectors is illustrated by:

$$\begin{bmatrix} Nrm \\ P+1 \\ P-1 \end{bmatrix} = \begin{bmatrix} 0 & -1 & 1 \\ R1 & G1 & B1 \\ R-1 & G-1 & B-1 \end{bmatrix} \quad (10)$$

Ideally, if no color misregistration is present, then the matrix in Eq. (10) has rank one, and all three vectors in the matrix are linearly dependent. On the other hand, if color misregistration is detected, the control volume spanned by the three vectors is maximum, and the three vectors will form a basis vector which spans the three-dimensional color vector space. In reality, however, the control volume is usually not zero or maximum. The magnitude of the control volume size spanned by the three vectors provides only an estimate of the amount of red misregistration present in the image, by calculating the determinant of the matrix described of Eq. (10). If the determinant is zero, then no color misregistration is present. Otherwise, the amount of color misregistration will be the size of the absolute value of the determinant of matrix (10).

To solve the matrix for its determinant in Eq. (10) a Laplace expansion may be used. For convenience, the solution of the determinant is shown in Eq. (11):

$$\text{Determinant (matrix (Nrm, P1, P-1))} = R1\ (G-1+B-1) - R-1\ (B1+G1) \quad (11)$$

Eq. (11) represents the formula for calculating the amount of red color misregistration present in

that pixel.

It will be understood by one of ordinary skill in the art that the matrix and the determinant are both used to resolve the misregistration problem.

The Applied Art

U. S. Patent No. 5,477,335 to Tai describes a techniques for scanning B&W images on a color scanner. As such, Tai is not concerned about color misregistration, and, as the Examiner correctly points out in ¶ 5 of the Office action, Tai does not teach or suggest application of a 3-D color vector determinant to a misregistered pixel.

U. S. Patent No. 5,047,844 to Ikeda *et al.* describes use of *matrices* - not *determinants* - as a partial solution to color correction.

Baxes describes well known processing techniques for digital images.

The Claims

Claim 1 requires, *inter alia*, "...applying a three-dimensional color vector determinant to the misregistered pixel;..." The Examiner applied '844, col. 5 line 64 through col. 6, line 68. there is no mention of "determinant" in this portion of '884, nor in any other portion of any of the applied references. '884 uses a matrix; Applicants use the determinant (Eq. 9) derived from a matrix (Eq. 10) to correct the misregistration. '884 uses the matrix product M1, M2; Applicants use the determinant Nrm = (0, -1, 1). These are mathematically distinct processes, and use of the matrix product does not render use of a determinant obvious. In fact, the applied portion of '884 is merely a linear transformation wherein input CMY values are adjusted to compensate for spectral crosstalk in the RGB image sensors and/or in the CMY toners of the printing device. Claim 1 is allowable over the applied art.

Claims 2-5 and 6 are allowable with their allowable parent claim.

Claim 4 requires that determining whether the misregistered pixel is part of a character includes checking the gradient and checking the luminance of a pixel. The "text structure" detection, *cf.* Figs. 3a-3c, is not fully specified in the detailed description portion of the '335 reference. There are a number of methods which may be used, however. One method is a gradient computation; another is a template matching/correlation operation. Another is to compare the "+" pixels against the center pixel and independently compare the "-" pixels against the center pixel. All of the foregoing are comparison processes, and would result in some kind of score would which would be derived from the comparison results. It seems they are not trying to limit themselves to a particular method of text structure detection, but they are just describing a step of edge detection as an element of their overall method. Applicants have already determined whether an edge is detected, and are, in the recited step of Claim 4, attempting to determine whether the edge belongs to a character, thus, the claim is allowable over the applied art, because the applied art does not teach nor suggest checking gradient and luminance to determine whether a misregistered pixel is part of a character.

Claim 7 is allowable for the reasons set forth in connection with claims 1 and 4.

Claims 8-10 are allowable with their allowable parent claim.

Claim 11 is allowable for the reasons set forth in connection with claims 1 4 and 7.

Claims 12-13 are allowable with their allowable parent claim.

In light of the foregoing amendment and remarks, the Examiner is respectfully requested to reconsider the rejections and objections stated in the Office action, and pass the application to allowance. If the Examiner has any questions regarding the amendment or remarks,

the Examiner is invited to contact the undersigned.

Request for Extension of time in Which to Respond

Applicants hereby request a one-month extension of time under 37 C.F.R. § 1.136 in which to Respond. A PTO Form 2038 credit card authorization in the amount of $110.00 is enclosed. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any over-payment to Account No. 22-0258.

Customer Number

23855

Respectfully Submitted,

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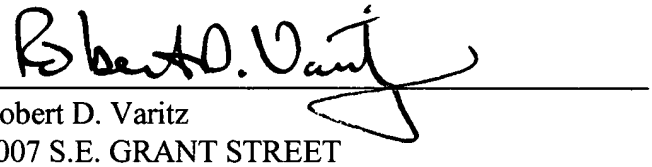

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